Fluvial deposits as an archive of early human activity

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Abstract

River terraces are well established as an important source of Lower and Middle Palaeolithic artefacts in Europe, large collections having been assembled there during the years of manual gravel extraction. Now that many terrace sequences can be reliably dated and correlated with the oceanic record, potentially useful patterns can be recognized in the distribution of artefacts. The earliest appearance of artefacts in terrace staircases, marking the arrival of the first tool-making hominins in the region in question, is the first of several archaeological markers within fluvial sequences. The Lower to Middle Palaeolithic transition, with the appearance of Levallois, is another. Others may be more regional in significance: the occurrences of Clactonian (Mode 1) industry, twisted ovate handaxes and bout coupé handaxes, for example. IGCP Project no. 449 instigated the compilation of fluvial records from all over the 'old world'. Comparison between British and Central European sequences confirms the established view that there is a demarcation between handaxe making in the west and flake/core industries in the east. Other centres of activity reported here have been in the Middle East (Syria), South Africa and India. Data from such areas will be key in deciphering the story of the earlier 'out-of-Africa' migration, that by pre-*Homo sapiens* people. There is clear evidence for diachroneity between the first appearances of different industries, in keeping with the well-established idea of northward migration.

1. Introduction

Much of the evidence for early human existence and activity, from the Lower and Middle Palaeolithic, is preserved within fluvial contexts from 'Old World' rivers. In Europe, the examination of such fluvial sequences in search of Palaeolithic artefacts has a lengthy pedigree and is responsible for the documentation of many exposures of river terrace sediments and the fossils that sometimes accompanied their artefact content. Before the development of absolute dating techniques, the chronology of the Palaeolithic was largely derived from the terrace sequences of northern Europe, making this area historically important in the development of Palaeolithic archaeology as a whole. The contribution of IGCP 449 to the European Palaeolithic fluvial record was reviewed by Bridgland et al. (2006). This paper looks additionally beyond Europe to areas such as the Middle East, India and South and North Africa, which have also seen IGCP 449 activity and have important evidence to bear on questions of human migration and activity during the Quaternary.

With the development of absolute dating techniques there has been a shift by archaeologists away from the

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study of fluvial records, as many such assemblages consist of more or less abraded artefacts derived from occupied land surfaces. Some recent investigations, however, have shown that this is not the case with all the fluvially derived assemblages. River-bed gravels, where they contained suitable lithologies, would have represented important resources for stone-tool making. It is clear that knapping sometimes took place on gravel bars, at channel edges and on ephemeral surfaces within floodplains, so that a range of contexts are found. The most important fluvial Palaeolithic sites are those in which the assemblages are of high integrity, with little abrasion and perhaps even conjoinable material, and where dating evidence is available, preferably by multiple means, thus allowing the fluvial sequence to be used as a chronological framework for the archaeological record (cf. Wymer, 1999; Bridgland, 2000; Bridgland et al., 2004a, 2006).

Although the availability of absolute dating in recent years has led to a lessening of the importance of terrace sequences, the recent correlation of the terrace sequences to the oceanic record has led to some important new inferences from the terrace sequences. Most absolute dating techniques have large errors, so that correlation by such means between individual Palaeolithic sites is quite ambiguous and even impossible. The correlation of the terrace sequences of NW Europe, which can provide a framework for the Palaeolithic record (Bridgland, 2000; Bridgland et al., 2006) is, therefore, of great importance. Palaeoenvironmental data from these archives is also important in understanding human adaptations and migrations during the Pleistocene.

Fluvial sediments are also an important repository of early archaeological evidence in Africa and India, although the records there and the research coverage are somewhat patchy. The early work in Africa concentrated on the fluvial sequences, of which the Vaal River, in South Africa, was the classic sequence. This earlier work has been overshadowed by the evidence coming from the caves in South Africa and the well-exposed lake and ephemeral stream sequences of East Africa. Ongoing work on the Vaal River is briefly reported here. In India, Palaeolithic artefacts occur in fluvial sediments of almost all the rivers of Peninsular India. Indian archaeologists have tried to find artefacts away from fluvial contexts, but such occurrences are rare and also suffer from destruction by geological processes. Mishra et al. (2003) have argued that the Indian rivers, being highly seasonal, are not very destructive of the archaeological context and are the most important agent for burying sites. Only buried sites survive from the Lower Palaeolithic period. Weathering on the surface is more destructive to sites than incorporation into fluvial deposits. Slow processes like weathering, acting continuously, are more destructive in the long run than fast processes acting for a short time. Thus artefacts discarded on bedrock surfaces have been destroyed by weathering, while those incorporated into fluvial deposits have survived (Mishra, 1982). Most of the earliest sites are found in fluvial deposits and some of these artefacts have been well preserved in fine-grained sediments.

It is tempting to see concentrations of Lower and Middle Palaeolithic find-spots in fluvial context as evidence that early humans favoured river valley locations. This is almost certainly due to the better opportunities for preservation and discovery in fluvial gravels, as mentioned above. During the life of IGCP 449 (2000 2004), its Palaeolithic subgroup monitored and promoted the types of archive described above, as documented in project annual reports (see Bridgland et al., 2007). This paper will review the most significant of these contributions, which are widely distributed (Fig. 1), under national and/or regional headings.

2. Britain

During the lifetime of IGCP 449 there was a surge of new activity in Britain, in part funded by the Government's 'Aggregates Levy Sustainability Fund' (ALSF). Primarily introduced to make recycling of aggregate economically viable, this levy on new aggregate extraction has funded a number of projects that have enhanced knowledge of fluvial Palaeolithic records and continue to do so (Table 1).

The ALSF has not only provided an important source of funding for research into Quaternary deposits and their contained Palaeolithic material, but has also founded a working relationship between Quaternary scientists and commercial quarry companies. Access to Pleistocene deposits is largely dependent on the large-scale extraction of fluvial sands and gravels and such quarries have the potential to provide a great deal of data. Several projects noted here have conducted much of their research within active sand and gravel quarries throughout Midland and southern Britain and range from studies of entire fluvial systems (e.g. the Trent and Medway Palaeolithic Projects) to detailed studies of single sites (e.g. Welton-le-Wold, Lincolnshire).

During much of this period the 'Ancient Human Occupation of Britain' project, funded by the Leverhulme Trust (commenced Autumn 2001), has facilitated new research at several important fluvial localities, some in response to chance new discoveries. These have included, by way of example, (1) work on Early Middle Pleistocene marine and fluvial sediments at Norton Subcourse, Norfolk, which will provide an important biostratigraphical constraint on the fluvial sediments of the Ingham/Bytham River (cf. Rose, 1994; Rose et al., 1999, 2001, 2002; Lee et al., 2006); (2) the excavation of an organic deposit containing mammoth remains and artefacts in a low terrace of the River Wissey, at Lynford, Norfolk, and (3) the discovery vertebrate remains (including woolly rhinoceros, horse, mammoth and reindeer) in low terrace deposits of the River Trent system at Whitemoor Haye, near Alrewas, Staffordshire. Perhaps the most significant, however, is research on fluvial and estuarine sediments on

Fig. 1. Location of sites and rivers discussed in the text.

Table 1
Palaeolithic fluvial projects in Britain funded by the Aggregates Levy Sustainability Fund

Project	Ref.	Duration
Welton-le-Wold, Lincolnshire (Palaeolithic site in Lincolnshire, artefacts from gravel of minor river)	3447 main	2003
Palaeolithic Archaeology of the Sussex/Hampshire Coastal Corridor (Solent River terraces)	3279 anl	2003
Archaeological Potential of Secondary Contexts (Palaeolithic archaeology from gravels)	3361 main	2003–04
Happisburgh/Pakefield Exposures (early Palaeolithic sites in East Anglia)	4600 main	2005
Medway valley Palaeolithic project	3836 anl	2005–07
National ice age network	3790 main	2005–07
Trent valley Palaeolithic project	3495 anl	2005–07
Palaeolithic Rivers of South-West Britain	3847 pils	2005–07
Palaeolithic Archaeology of the Cambridgeshire Washlands (Wash basin rivers)	5266 main	2007

the Suffolk coast at Pakefield, which has pushed the earliest human occupation of Britain and, indeed, northern Europe further back into the Cromerian Complex (Parfitt et al., 2005).

Other advances in Britain during the course of IGCP 449 have stemmed from developer-funded archaeological assessment and excavation. Key projects have included the Channel Tunnel Rail Link, associated with which have been investigations of two of the Thames valley's most important Palaeolithic sites, at Ebbsfleet (cf. Wenban-Smith, 1995, 2001) and Purfleet (cf. Schreve et al., 2002). In addition, a new primary-context site has come to light at Southfleet Road, south of Swanscombe, where artefacts and animal remains have been excavated from south-bank Thames tributary deposits (Wenban-Smith et al., 2006; see below).

Finally, new techniques have been applied to gain a better understanding of the ages of river terraces in southern England. The terraces of the erstwhile Solent River and its many tributaries have yielded significant artefact assemblages (Harding, 1998; Hosfield, 1999; Wymer, 1999; Wenban-Smith et al., 2000) but have always been difficult to date because they contain little biostratigraphical evidence or material suitable for radiometric measurements. There have been two recent innovations, however. First, uplift/incision modelling has been applied to the terraces of the Solent system, as well as to marine terraces in the same region, using artefact assemblages along with the meagre palaeontological data as means for constraining their ages (Westaway et al., 2006). In particular, the first appearance of Levallois technique in the Solent sequence is taken to represent an age around MIS 9-8. This key constraint is complemented by others (in approximate order of importance) arising from the first appearance of artefacts (~MIS 13), the occurrence of Mousterian bout coupé hand axes (MIS 3-cf. White and Jacobi, 2002) and hand axe assemblages with a significant proportion of twisted ovate forms (MIS 11-10; cf. White, 1998). In the second recent innovation, age estimates from an OSL dating programme on Solent terrace gravels (Briant et al., 2006), undertaken as part of the ALSF project '*Palaeolithic Archaeology of the Sussex/Hampshire Coastal Corridor*' (Table 1), have provided broad support for the Westaway et al. dating scheme.

2.1. The Southfleet road Clactonian site

Archaeological rescue excavations ahead of construction of the Channel Tunnel Rail Link have been taking place in the Ebbsfleet Valley, south-east of Swanscombe, since 1997. In September 2003, construction works revealed a complex sequence of Quaternary deposits, including fluvial and possible lacustrine elements, containing lithic artefacts and palaeoenvironmental remains (Wenban-Smith et al., 2006). Subsequent excavation revealed parts of the skeleton of a straight-tusked elephant (*Palaeoloxodon antiquus*), in association with a dense concentration of cores and flakes in mint condition, some with apparent use-damage. These can be interpreted as representing butchery of the elephant carcass. It is, however, uncertain whether the animal was hunted deliberately or whether it perhaps became mired and was scavenged. At an equivalent stratigraphical level on slightly higher ground, about 25 m away, a cluster of >1000 similarly mint cores and flakes was found, many with coarse notching and secondary flaking, typical of assemblages characterized as 'Clactonian'. A range of palaeo-environmental remains, including pollen, molluscs and small vertebrates, was also present. These indicate temperate-climate conditions with local woodland and suggest attribution to the Early Temperate pollen biozone IIc of an interglacial. The combination of biostratigraphy and terrace correlation suggests equivalence with the Swanscombe deposits; key fauna include pine vole (*Microtus subterraneus*) and narrow-nosed rhinoceros (*Stephanorhinus hemitoechus*), which provides a maximum age, and the fern *Azolla*. This would imply that the interglacial is equivalent to MIS 11 and that the sequence is similar in age to the Swanscombe Lower Loam, which has yielded an important Clactonian assemblage (cf. Conway et al., 1996). While analysis of the excavated material is still at an early stage, the site has potential to improve the understanding of hominin adaptations at this time and contribute to the contentious debate over the presence or otherwise of a separate Clactonian population (i.e. not making handaxes) early in MIS 11 in southeast England (cf. McNabb and Ashton, 1992, 1995; Wenban-Smith, 1998; White, 2000; White and Schreve, 2000). Such considerations are of major significance in understanding patterns of human activity and occupation in NW Europe during the Middle Pleistocene.

3. Northern France

France, where many of the Lower and Middle Palaeolithic type localities are to be found, has a fluvial Palaeolithic record of unparalleled importance. The IGCP 449 project has coincided with reviews of terrace sequences in a number of French valleys, most notably in conjunction with the Fluvial Archives Group (FLAG) 2002 conference in Clermont Ferrand. These include, in the north, the Yonne (Chausé et al., 2004), the Moselle and the Meurthe (Cordier et al., 2004).

The information from here was reviewed recently by Bridgland et al. (2006), so the foregoing will be restricted to highlights. Significant advances have been achieved during the past decade, some of which challenge former received wisdom. Perhaps the most significant is the discovery of artefacts (Middle Palaeolithic) in a tufa at Caours, in the Somme, that is thought to date from the Eemian. Its geochronological age, based on U/Th and TIMS results (average from 10 dates), of 122 ka BP, coupled with its low position within the Somme terrace sequence, makes the evidence from Caours the most convincing to date for a Last Interglacial human presence in Atlantic NW Europe (Antoine et al., 2006; Antoine et al., 2007). This implies that the contemporaneous absence from Britain (Sutcliffe, 1995; White and Schreve, 2000) results from insularity rather than reflecting a wider regional migration pattern.

A particular highlight of French project activity was research undertaken at the Acheulian type locality, St Acheul, in the outskirts of Amiens, in the valley of the River Somme. The Somme terrace sequence is well known (Antoine et al., 2000, 2007); its chronology has been established from several independent lines of evidence, including palaeomagnetism, uranium series and ESR dating, palaeosol sequences in colluvial overburden, and mammalian biostratigraphy, as summarized by Antoine et al. (2007). The St Acheul type locality coincides with the Garenne Formation (see Antoine et al., 2007, Fig. 5), aggradation of which is ascribed to the Elsterian (MIS 12). During the recent investigations, in preparation for work to make the gravel pits complex accessible to the public, an interglacial tufa was discovered (Antoine and Limondin-Lozouet, 2004). The molluscan assemblage from this tufa resembles that from a similar deposit in the Seine valley, at St Pierre lès Elbeuf, attributed to MIS 11 (Lautridou et al., 1974; Rousseau et al., 1992). Indeed, this distinctive fauna occurs at a range of tufa sites in north-west Europe and has given rise to the term '*Lyrodiscus biome*' (Rousseau et al., 1992). ESR dating to the St Acheul tufa, yielding an age estimate of 403 ± 73 ka (Bahain et al., 2001), suggests that it too was formed in MIS11 (Antoine and Limondin-Lozouet, 2004; Limondin Lozouet and Antoine, 2006). The dated tufa at St Acheul corroborates other geochronological data from *Lyrodiscus*-bearing tufa sites, such as the U-series and TL dates from Beeches Pit, West Stow, England (Preece et al., 2007). The tufa at St Pierre-lès-Elbeuf, feared to have been quarried away, has been rediscovered recently (Bridgland et al., 2006).

4. Germany

Palaeolithic assemblages from German rivers are less well known than from France and Britain, despite the relatively high incidence of human fossils from fluvial contexts in Germany. The latter include, in age order, Mauer, from the River Neckar near Heidelberg (MIS 13), finds from Bilzingsleben, from the River Wipper near Weimar and Steinheim, from the River Mur (tributary of the Neckar) near Stuttgart (both MIS 11), and Weimar-Ehringsdorf, in the Ilm valley (Mania, 1995; Schreve and Bridgland, 2002; Bridgland et al., 2004b).

A Quaternary Research Association meeting in Thuringia in 2002, which contributed to IGCP 449, visited Bilzingsleben and Ehringsdorf; the field guide (Meyrick and Schreve, 2002) included reviews of the evidence from these and other fluvial localities. In addition to their hominin fossils, both Bilzingsleben and Ehringsdorf have travertine accumulations that preserve evidence of the human use of fire. The Ehringsdorf travertine overlies the gravel of Ilm Terrace 4 and is attributed, despite some controversy, to MIS 7 (Schreve et al., 2002; Bridgland et al., 2004b). At a lower level within the Ilm terrace sequence, in association with Ilm Terrace 5, another travertine occurs at Taubach (Fig. 2, see Schreve et al., 2007), this time attributed to MIS 5e, the Eemian Interglacial. The occcurrence of an artefact assemblage from this deposit indicates a human presence in central Europe during the Last Interglacial. Travertines of this sort, formed by calcareous springs on the valley floors during interglacial episodes, are common on Muschelkalk bedrock, as in the Weimar area. They also occur above the Neckar terraces (for example, the Eemian travertine at Stuttgart-Untertürkheim; van Kolfschoten, 2000). As well as being highly fossiliferous, presenting opportunities for biostratigraphy, the travertines can be dated using techniques such as the U series (Harmon et al., 1980; Blackwell and Schwarcz, 1986; Schwarcz et al., 1988; Frank et al., 2000; Mallick and Frank, 2002). Travertine precipitation can preserve dwelling and activity surfaces, as is evidenced by the hearths recorded at Ehringsdorf and Bilzingsleben.

It is the Bilzingsleben II travertine, ~30 m above the Wipper (Fig. 1, see Schreve et al., 2007), that contains the celebrated Bilzingsleben hominin fossil and occupation site, the archaeological assemblage from which was summarized recently by Mania and Mania (2003). Preservation in travertine has allowed bone, tusk and wooden artefacts to survive, as well as lithics. The last-mentioned are dominantly small, made from glacially-transported clasts, leading to the classification of the assemblage as 'Lower Palaeolithic Microlithic Tradition' (LPMT; e.g. Burdukiewicz and Ronen, 2003), of a general type that is characteristically found in central Europe (Valoch, 1984,

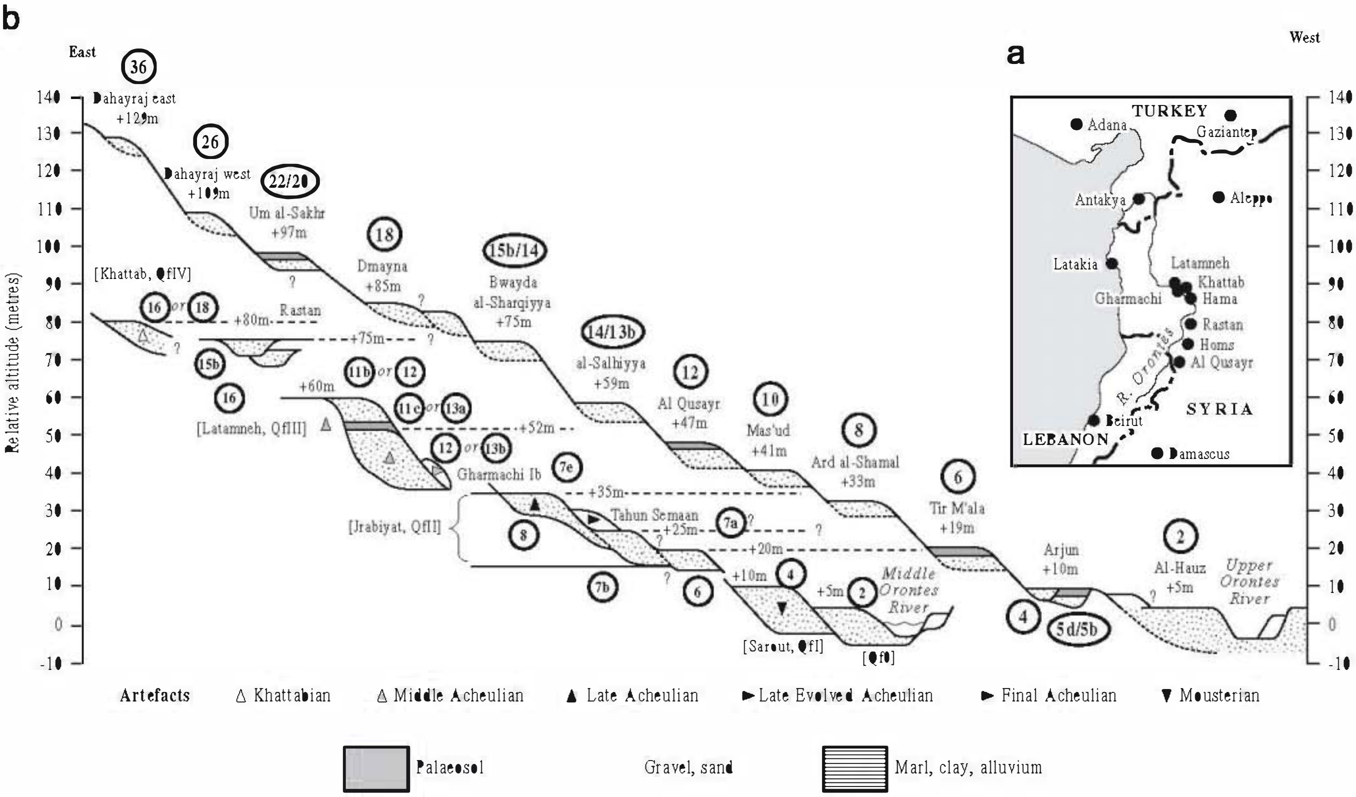

Fig. 2. The terraces the Upper Orontes valley, Syria: (a) location map; (b) idealized transverse section through the Orontes terrace sequence in the Homs area (modified from Bridgland et al., 2003). Bases of terraces and other field relations are shown dashed if not directly observed. Numbers in circles indicate MIS correlations. Terrace and archaeological evidence from the Middle Orontes (Besançon and Sanlaville, 1993; Dodonov et al., 1993; Muhesen, 1993) is shown, for comparison, to the left of the main staircase.

2003; Moncel, 2003; Bridgland et al., 2006). The lithic assemblages from Ehringsdorf and Taubach have also been regarded as examples of LPMT (Bridgland et al., 2006). Despite the fact that larger pieces (up to 100mm) are included, handaxes are lacking, although some tools, including bone examples, are bifacially worked (cf. Brühl, 2003; Mania and Mania, 2003).

In addition to the above-mentioned terraces, an important fluvial sequence has come to light in recent years in a subsiding basin related to halokinesis. This is the succession of 'en echelon' channel fills recorded in the open-cast lignite mine at Schöningen, near Magdeburg. The dating framework for this locality is not entirely certain (cf. Bridgland et al., 2006), but it clearly includes sediments ranging from Holsteinian to Holocene. Most significant archaeologically is the Schöningen II channel, attributed to the Reinsdorf interglacial, which has yielded several wooden artefacts, interpreted as throwing spears and hafts for stone points (Thieme, 2003). Although widely attributed to MIS 9 (Urban, 1995; Urban et al., 1995; van Gijssel, 2006), there are grounds for considering the Reinsdorf interglacial to be equivalent to part of MIS 11 (Mania, 1995; Schreve and Bridgland, 2002; Schreve et al., 2007). Artefacts also occur in the Schöningen I deposits, in the form of small flakes and flake-tools, in the company of burnt flints from which TL ages of >400 ka have been obtained (Thieme, 2003). Once again the lithics are dominantly small, implying the use of limited raw material resources, and lack both handaxes and Levallois cores.

The lithic assemblages from all these German sites, which range in age from MIS 11 (Bilzingsleben II and, with less certainty, Schöningen II) to Last Interglacial (Taubach), generally lack handaxes and are dominantly flake/core industries, often showing the diminutive artefact size of LPMT assemblages, possibly a reflection of poor quality raw material, probably glacially derived. The extent to which this raw material control explains the regional pattern of handaxe occurrence in northern Europe, which is generally restricted to France and Britain, is a continuing subject of debate. The regions of prolific handaxe occurrence in southern Britain and northern France are related to chalk bedrock with primary sources of high quality nodular flint. Away from these flint heartlands, non-flint raw materials, such as orthoquartzite, do not necessarily lend themselves to handaxe manufacture due to their mechanical properties (although exceptional examples exist). Glacially transported flint tends to be of smaller size and much lower quality, due to incipient frost-fracturing, and is likely to exercise a higher degree of control over tool production and form in areas where fresh flint is unavailable. In the Trent Valley, an area at the known northern limit of hominin occupation in Britain and which lacks primary sources of flint, assemblages contain both flint handaxes and non-flint (quartzite) core and flake assemblages, suggesting that in such areas high-quality flint may have been opportunistically used when encountered within gravel deposits (Bridgland et al., in press; White et al., in press). This may also be the case at Bilzingsleben, where quartzite chopping tools are present, as well as large flint tools amongst the assemblage of predominantly small artefacts.

5. Central and Eastern Enrope

Moving further eastwards into the countries of the former Warsaw Pact, a similar absence of handaxes and predominance of dominantly small flake/core artefacts is again apparent. There has been participation in IGCP 449 from the Czech Republic, Hungary, Bulgaria, Poland, Moldova and Ukraine, each of which has sites contributing to this pattern of evidence. Data from the Czech site at Račinēves, in the Vltava valley (Tyráček et al., 2004), and Vértesszölös, Hungary (Kretzoi and Vertes, 1965; Kretzoi and Dobosi, 1990; Moncel, 2003), were reviewed recently by Bridgland et al. (2006), so brief mentions will suffice here. The Račinēves deposits, part of the Straškov 2 terrace of the Vltava, is another with a diminutive non-handaxe (LPMT) lithic assemblage of a type characteristic of central Europe (Bridgland et al., 2006). Its association with a mammalian fauna, including *Stephanorhinus kirchbergensis* and *S. hemitoechus* (indicating a post-Elsterian age) and *Arvicola terrestris cantiana* (= *A. mosbachensis*) molar teeth of characteristic Holsteinian morphology (cf. Tyráček et al., 2001), led Tyráček et al. (2004) to suggest an MIS 11 age. The lithic assemblage includes cores, notches, knives, scrapers, wedges and hammerstones, almost all made of Proterozoic ‘lydite’ and some in fresh condition, indicating a primary or near primary context (Tyráček et al., 2001; Fridrich and Sýkorová, 2003). Vértesszölös, a travertine site in the valley of the Tata (a tributary of the Danube) has a comparable lithic assemblage but is clearly older, being associated with an early Middle Pleistocene mammalian assemblage, notably containing *Pliomys episcopalis*, *Stephanorhinus hundsheimensis* and *Ursus deningeri* (Kretzoi, 1990; Jánossy, 1990). Critically, the water vole is *Arvicola terrestris cantiana* (e.g., Jánossy, 1990), which further constrains the age to late within the Cromerian Complex (cf. Preece and Parfitt, 2000). As well as the fauna and lithic artefacts, the travertine has also yielded human fossils and bone tools and, like the travertines at Bilzingsleben and Ehringsdorf, evidence of fire use by hominins (e.g. James, 1989). A final key age indicator is *Microtus gregalis*, which appears at Vértesszölös only in the upper part of the travertine and in overlying loess (Kretzoi, 1990; Jánossy, 1990). An age late in MIS 13 thus seems likely (Bridgland et al., 2006).

5.1. *The East European Plain*

Lower and Middle Palaeolithic sites are rare on the East European Plain, where the first immigration of hominins was perhaps as late as MIS 11 (Rekovets et al., 2007). One site that might represent an earlier hominin presence is at Pogrebya, eastern Moldova, in the lower River Dniester. The Middle and Upper Dniester flows through Late Cretaceous Chalk, providing flint for tool-making (e.g., Łanczont and Madeyska, 2005). This river also has the best-developed terrace staircase in the region (Matoshko et al., 2004; Bridgland and Westaway, 2007). Praslov (1995) reported small flake artefacts from a palaeosol overlying Dniester terrace VI, which corresponds with the Koshnitsa terrace of Matoshko et al. (2004), ~60 70 m above present river level (Fig. 4, see Schreve et al., 2007). Praslov attributed the palaeosol containing the Pogrebya artefacts to the Likhvin interglacial (= MIS 11; cf. Hoffecker, 1999). This terrace is also observed at Kolkotova Balka (Kolkotov Ravine) at Tiraspol, in eastern Moldova, the stratotype for the Tiraspol mammal biozone of eastern Europe, important in that it contains the vole *Mimomys savini*. According to Matoshko et al. (2004), the Koshnitsa (No. VI) terrace dates from MIS 16, the time of the Don glaciation, which is in keeping with the faunal evidence. Attribution of the palaeosol to MIS 11 was influenced by the former belief that the Don glaciation dated to MIS 12 (cf. Aleksandrova, 1994); given the current interpretation of the Dniester sequence, an older age, perhaps as old as MIS 15, is plausible.

Evidence for Middle Pleistocene hominin occupation of the region has been further documented from a fluvial site in the terrace system of the next river east from the Dniester, the smaller Yuzhny Bug system (Rekovets et al., 2007). This site is at Medzhybozh, Ukraine, in the 3rd Terrace of the Yuzhny Bug. Rekovets et al. (2007) documented two superimposed alluvial cycles here, both with significant mammalian faunas (see Schreve et al., 2007). The lower of these cycles includes a Palaeolithic layer (‘unit 16’) from which ‘heavy-hammer’-struck flint flakes were recovered, a few of which were illustrated by Rekovets et al. (2007, Figs. 6 and 7). The best evidence for determining the age of this assemblage comes from mammalian biostratigraphy, including water vole tooth-morphology, and this led Rekovets et al. to ascribe it to MIS 11. Two flakes of apparently more advanced type were also recovered from later non-fluvial sediments overlying the 3rd Terrace deposits at Medzhybozh; these were interpreted by Rekovets et al. as possible Middle Palaeolithic artefacts, perhaps indicating a lengthy human presence in the East European Plain.

Another Middle Palaeolithic fluvial site in the region occurs at Korolevo, western Ukraine, in a terrace of the River Tisza (Koulakovskaya, 1999). Levallois technology is reported here from a bed (Layer VI) dated by TL to >350 ka, possibly MIS 10; a higher layer here (Va), with ‘leaf-point shaped fragments’, is attributed to MIS 7

(Kozlowski 2003). According to Kozlowski (2003), this site lies outside the zone of Acheulian (handaxe) distribution (see below)

5.2. *Bulgaria*

Other important evidence from eastern Europe comes from cave sites, significant amongst which is the Kozarnika cave, on the southern flanks of the Danube valley near Belogradchik, in NW Bulgaria. This has yielded arguably some of the oldest artefacts in Europe, dated to the Early Pleistocene (Guadelli et al., 2005). Again this is a non-handaxe artefact assemblage, its great antiquity being indicated by a stratigraphical position below the Matuyama-Bruhnes palaeomagnetic reversal and by an associated vertebrate fauna with *Microtus* (*Allophaiomys*) *deucalion*. Cave evidence is not entirely separate from the fluvial record, in that actively forming cave levels are controlled by contemporaneous water tables and, therefore, valley floors. Heights above river level can thus give a useful indication of age (e.g. Farrant et al., 1995), one that can frequently be calibrated with reference to datable speleothem.

5.3. *Georgia*

Georgia is credited with the earliest European Palaeolithic evidence, from the fluvio-volcanogenic human-fossil site at Dmanisi, in the confluence area of the Mashavera and Pinezauri rivers (Gabunia and Vekua, 1995; Gabunia et al., 2000; de Lumley et al., 2002). About 90 m above present river level, the hominin level is constrained by Ar Ar dating of overlying and underlying basalt lavas to ~1.8 Ma, an interpretation supported by normal palaeomagnetic polarity, indicating the Olduvai subchron. The artefacts represent a flake industry made from lithified tuff or quartz (Ljubin and Bosinski, 1995). Other sites in the Caucasus region, including caves, were reviewed by Bridgland et al. (2006). Cave sites, such as Kudaro I and III and Treugol'naya, have provided abundant evidence of human occupation in the Greater Caucasus during the early Middle Pleistocene, their interpretations reinforced by biostratigrahy and geochronology (Ljubin and Bosinski, 1995). The Kudaro I cave in NW Georgia, ~260 m above the adjacent valley floor of the Dzhodzhori River (~1600 m a.s.l.), contains basal sediments with reversed magnetic polarity, overlain by levels yielding a diverse assemblage of thousands of artefacts (including hand axes) associated with characteristic Cromerian Complex mammals, such as the bear *Ursus deningeri* and the rhinoceros '*Dicerorhinus etruscus*' (= *Stephanorhinus hundsheimensis*). Ljubin and Beliaeva (2004) have suggested, from TL dates (the oldest of which is 360 ± 90 ka), that the earliest artefacts here date from MIS 11, but the association with a Cromerian Complex fauna, coupled with the growing consensus that MIS 11 is equivalent to the Holsteinian (cf. Rowe et al., 1999; Grün and Schwarcz, 2000; Kukla, 2003; Geyh and Müller, 2005; Preece et al., 2007), suggests that this age determination is an underestimate. In nearby Kudaro III cave, situated 30 40 m closer to the Dzhodzhori valley floor, the earliest evidence of human occupation (in levels 6 8a) is of a handaxe-making culture, associated with Cromerian Complex mammalian taxa such as *Ursus deningeri* (Ljubin and Bosinski, 1995). TL dating (bed 8a) indicates an age of 560 ± 112 ka (Derevianko and Petrine, 2004), suggesting occupation during MIS 15.

The other Cromerian Complex cave site, Treugol'naya cave, adjoins the valley of the River Urup, a left-bank tributary of the Kuban, which flows into the Sea of Azov. This site has yielded a small assemblage of handaxes and other artefacts in beds also containing *Arvicola cantiana*, *Ursus deningeri*, *Stephanorhinus hundsheimensis*, *Cervus elaphus acoronatus* (archaic red deer) and *Bison schoetensacki* (Ljubin and Bosinski, 1995). TL dating indicates that bed 7a, at the base of the series of 'Acheulean' levels, has an age of 538 ± 25 ka (Derevianko and Petrine, 2004), suggesting human occupation in MIS 13, consistent with the joint presence of *Arvicola* and other Cromerian Complex mammals.

Ljubin and Bosinski (1995) also reported artefacts from open sites such at Cimbal quarry, at Kurgan in the Taman Peninsula, where a few flake artefacts were found in association with abundant mammal bones, some possibly fractured during butchery. Mammalian biostratigraphy places the occupation here at around the Early to Middle Pleistocene boundary (Ljubin and Bosinski, 1995; cf. Markova, 2005). At Gerasimovka, on the north shore of the Gulf of Taganrog (Sea of Azov), a coarse fluvial gravel at ~45 m a.s.l. has yielded artefacts, mostly flakes and lacking handaxes (Praslov, 1995). Again mammalian faunal evidence point to an age around the Early to Middle Pleistocene transition. The gravel at Gerasimovka is attributed to fluvial transport along the Manych palaeochannel, the outlet spillway that connected the Caspian and Black Seas during Caspian highstands (e.g., Praslov, 1995; Mitchell and Westaway, 1999).

6. Southern Europe

6.1. *Central and Southern France*

The fluvial sequence in the Massif Central region of France was the topic of an IGCP 449/Fluvial Archives Group meeting in 2002, during which the terraces of the Allier were reviewed (cf. Pastre, 2004; Westaway, 2004). In this region there has been much discussion regarding the human origin of potential artefacts made of local basalt, thought to date from around the Plio-Pleistocene boundary, in the French Massif Central. It now seems probable that these 'tephrofacts' formed as a result of natural processes (Raynal et al., 1995a). Further north, 'pebble culture' artefacts have been found in situ in high fluvial terraces of a number of river systems, such as terrace I (52 m above river level) of the Loir, a right-bank tributary of the larger River Loire (Despriée et al., 2004, 2005; Voinchet et al., 2005). Although not yet dated, the stratigraphical position of this site relative to younger, dated terraces suggests a probable age of ~1 Ma. A comparable site that has been dated is the Pont-de-Lavaud pebble-culture site, situated in Terrace D of the river Creuse, a left-bank tributary of the Loire (Despriée et al., 2004, 2005; Voinchet et al., 2005). A total of 10 ESR dates have been determined for this terrace (Despriée et al., 2004), ranging from 905 ± 100 to 1187 ± 200 ka. The weighted mean of these dates is 1034 ± 57ka ($\pm 2\sigma$). Excavated between 1984 and 1994, the archaeological discoveries were within and immediately above the basal deposits of Terrace D, in the latter case including 'anthropic pavements' of quartz blocks. The artefacts, dominantly quartzose, number ~5000 and include pebbles broken on anvil stones (Despriée et al., 2004).

Cave sites have again yielded important evidence in southern France, the earliest handaxes in this region having been claimed from the 'Sol P' stratigraphical level in the Caune de l'Arago cave, near the Mediterranean coast of SW France at Tautavel. Overlying speleothem dated to ~600 ka, this level and its handaxe industry have been attributed to MIS 15-14 (Barsky and de Lumley, 2005). The Orgnac 3 site in the Ardèche (SE France) is important for providing geochronological control on the appearance of Levallois technique, which is dated by U-series and ESR to 309 ± 34 ka (Moigne and Moncel, 2005); i.e. MIS 9. These key markers are reinforced by artefact distribution in fluvial sequences, with handaxes appearing for the first time in the Loir (tributary of the Loire) in Terrace F, base 22 m above the river and dated 482 ± 77 and 491 ± 75 ka by ESR (Despriée et al., 2004, 2005). In the same terrace sequence, Levallois occurs in the upper gravel of Terrace B (base 6 m above the river), above sand ESR dated 241 ± 42 ka (Despriée et al., 2004, 2005).

6.2. *Iberia*

The record from the Iberian Peninsula was reviewed in some detail by Bridgland et al. (2006) so a brief overview will suffice here. This is an important area in that it is on a potential alternative migration route from Africa to Europe, via the Strait of Gibraltar (Roebroeks, 2001; Straus, 2001). Lower Palaeolithic artefacts from fluvial contexts in Iberia occur particularly in the rivers draining to the Atlantic, including the Duero, Tagus, Guadiana and Guadalquivir, and are lacking from the Ebro and the rivers draining to the central/southern Mediterranean coastline (Bridgland et al., 2006). The earliest well-dated evidence of human occupation is the presence of non-handaxe ('Mode 1') lithic industries in bed 3 at Fuente Nueva, in the upper part of the stacked fluvial/lacustrine sequence of the Guadix-Baza basin, which has reversed magnetic polarity (Matuyama chron) and is associated with Lower Pleistocene faunas including *Mammuthus meridionalis* and species of *Allophaiomys* (Martínez-Navarro et al., 1997, 2005). 'Mode 1' artefacts are also present in the Atapuerca karstic system (Carbonell et al., 1995, 2001) in levels just below the Matuyama-Brunhes reversal (Parés and Pérez-González, 1995, 1999). The widespread presence of Early Pleistocene hominins is also suggested by comparable Mode 1 assemblages from river terraces, such as Terraces T8 T12 of the Tagus, which also pre-date the Matuyama-Brunhes boundary (Pinilla et al., 1995; Santonja and Pérez-González, 2000 2001; Santisteban and Schulte, 2007). Other fluvial contexts for Mode 1 occurrences, of apparent early date, are the 75 m terrace of the River Valderaduey (Santonja and Pérez-González, 2000 2001), the 70, 80 and 60 m terraces of the Pisuerga and the 100 and 62 m terraces of the Tormes (Santonja and Pérez-González, 1984).

The first appearance of Acheulian artefacts is probably best constrained by cave evidence; such as in the Atapuerca system, in which hand axes first appear in the oldest levels to contain *Mimomys savini* (Raposo and Santonja, 1995), implying an age around MIS 15 (cf. Westaway et al., 2002). The handaxe makers may have crossed the Gibraltar Strait from Morocco, where the earliest Acheulian assemblages (from the Casablanca area) appear from magnetostratigraphy to date from the latest part of the Matuyama chron (~850 ka, or MIS 21; Raynal and Texier, 1989; Raynal et al., 1995b, 2002). Important Iberian Acheulian sites that can be linked to fluvial records include Torralba, which is in a largely lacustrine sequence lying between the 35 and 22 m terraces of the River Masegar, in the area between the Duero and Ebro (Perez-González et al., 1997). Another is Ambrona, ~39 40 m above the same river (Perez-González et al., 1997). Correlation with the travertines capping the upper Henares terraces, which are well-dated using the U-series method (Benito et al., 1998), suggests ages of MIS 12 8 for Torralba and pre-MIS 12 for Ambrona, consistent with mammalian biostratigraphical evidence (Soto et al., 2001). Handaxes first appear in the Tagus system in the 60 m terrace of the Sangrera tributary, considered equivalent to Tagus terrace T13 (Santonja and Pérez-González, 2000 2001; Santisteban and Schulte, 2007), which dates from the Early-Middle Pleistocene boundary, based on palaeomagnetism (Pinilla et al., 1995). Acheulian persists in the Tagus to ~MIS 6, based on its occurrence in T19 (Benito et al., 1998; Santisteban and Schulte, 2007).

As noted by Bridgland et al. (2006), Middle Palaeolithic (Levallois or Mousterian) sites are mainly in caves; at Atapuerca Levallois first appears in levels dated by ESR and U-series to 337 ± 29 ka (Falguerés et al., 1999). Rare records of Mousterian from fluvial contexts include terraces T13 (13 14m) and T14 (6 8m) of the Guadalquivir, dated with reference to calcrete capping higher/older terrace T12, which has given U-series dates of ~80 ka (Díaz del Olmo et al., 1989, 1993; Baena and Díaz del Olmo, 1994). In the Guadiana, Mousterian occurs in the 1 2 m terrace, TL-dated to 121 ± 14 ka (Rendell et al., 1994).

6.3. Italy

In Italy the earliest unequivocal evidence for human occupation may well date back to the Early Pleistocene. At Monte Poggiolo (near Forli in Emilia-Romagna, NE Italy), for example, a rich assemblage of artefacts made from small flint pebbles has been recovered from deltaic gravels associated with fossiliferous sands dated (ESR and palaeomagnetism) to ~1 Ma (Antoniazzi et al., 1993; Mussi, 1995). Another early site is Isernia La Pineta, in Molise, dated to ~600 ka (e.g., Minelli and Peretto, 2005), where more than 10,000 lithic artefacts have been found in association with mammal fossils within interbedded fluvial and lacustrine sediments. An important issue in relation to the Italian record concerns the possibility of human migration across the central Mediterranean Sea from Tunisia into Sicily and southern Italy. It is well known that early Middle Pleistocene archaeological sites in southern Italy provide evidence of handaxe-making, an example being Notarchirico near Venosa in Basilicata. This is a fluvial site, in the Ofanto River system, dated to 640 ± 40 ka from associated volcanic tephra (Piperno and Tagliacozzo, 2001). At contemporaneous sites further north, such as Isernia La Pineta, mentioned above, only flake artefacts are known, leading to the suggestion of a separate immigration of handaxe makers from North Africa (cf. Bridgland et al., 2006).

7. The Middle East

Situated at the crossroads between Africa, Asia and Europe, the Pleistocene archaeological record of the Middle East has long been viewed as of central importance to understanding hominin migration patterns. Palaeolithic research in the region has traditionally focussed on stratified cave sequences, particularly those from the southern Levant. Although these sites have produced much important evidence relating to early human behaviour and technological decision making, focus on them has meant that the fluvial Palaeolithic evidence in the region has been subject to comparatively few studies. IGCP 449 has included data compilation from these important but under-researched archaeological repositories, notably through the study of the terrace deposits of the River Euphrates in northern and eastern Syria (Demir et al., 2007a, b), and the River Orontes in western Syria (Bridgland et al., 2003).

7.1. The Euphrates

Palaeolithic artefacts associated with terrace gravels of the Euphrates have been noted since the early 1940s (Pervès, 1945). However, research in the region has been sporadic and limited to opportunistic sampling from three geographic regions: around the town of Birecik in southeastern Turkey (Minzoni-Déroche, 1987; Minzoni-Deroche and Sanlaville, 1988), and along the Jerablous Qara Qozaq and the Raqqa Deir ez-Zor stretches of the Euphrates in Syria (Besançon and Geyer, 2003; Copeland, 2004). Six Quaternary fluvial formations have been recognized in these areas, Qf V, the oldest, to Qf 0, which is regarded as Holocene. Previously, age equivalence has been assumed between corresponding terrace formations along different reaches of the river (Besançon and Geyer, 2003; Sanlaville, 2004). Research carried out during IGCP 449 has used Ar Ar dating of basalt capping fluvial deposits along Raqqa Deir ez-Zor stretch of the Euphrates to establish a stronger basis for dating the Euphrates sequence (Demir et al., 2007). Two key localities investigated are Halabiyeh and Zalabiyeh, ~40 km upstream of Deir ez-Zor and ~70 km downstream of Raqqa. Near Halabiyeh, in the right side of the modern river valley, basalt capping Euphrates gravel ~110 m above the modern river has yielded an Ar Ar date of 2717 ± 20 ka. At Zalabiyeh, in the left side of the valley, ~5 km further downstream, basalt capping Euphrates gravel ~40 m above the modern river has yielded an Ar Ar date of 2116 ± 39 ka. Although neither of these localities has produced unequivocal evidence for a human presence on the Euphrates at such early dates, sizable collections of cores and flakes have been recovered (e.g., Copeland, 2004) from three exposures of Qf III fluvial gravels ~20 km upstream at Madan. Surface uplift modelling suggests that the aggradation of these gravels can be correlated with the emplacement of those at Zalabiyeh (Demir et al., 2007), also ~40 m above the present river level, so the Madan artefacts could possibly indicate human occupation in Euphrates Valley by 2 Ma, representing some of the earliest evidence for a hominin presence outside Africa.

The majority of the artefacts collected from Pleistocene fluvial deposits between Raqqa and Deir ez-Zor are from younger sediments, assigned to terrace Qf II (see Copeland, 2004). Although no direct chronological indicators are available for any of these deposits, a basalt flow overlying sediments (as low as ~10 m above present river level) assigned to terrace Qf I at Ayash, ~10 km NW of Deir ez-Zor, has produced a weighted mean Ar Ar date of 402 ± 11 ka (Demir et al., 2007a). The assemblage from Ain Abu Jemaa, ~5 km upstream of Ayash, is an exemplar of the material recovered from deposits assigned to terrace Qf II in this area, producing some 447 artefacts including migrating platform cores, handaxes and flakes (Copeland, 2004). These deposits, which reach up to ~25 m above present river level, can be inferred on the basis of the existing terrace stratigraphy to pre-date MIS 12, given the above Ar Ar date; Demir et al. (2007a) tentatively estimated an age of circa MIS 22 for these deposits of terrace Qf II.

Few artefacts have been recovered from fluvial deposits assigned to terrace Qf I between Raqqa and Deir ez-Zor. Pervès (1964) reported 'Levallois-like' artefacts from deposits of this terrace beneath the basalt at Ayash and Copeland (2004) and Sanlaville (2004) discussed similar artefacts in deposits ~10 m above the present level of the Euphrates at Abu Chahri.

In the Jarablus area, further upstream, artefacts have been recovered only from fluvial deposits assigned to terraces Qf II and Qf I (see Copeland, 2004). Demir et al. (2007a) have suggested that the Qf II and I deposits in the Jarablus area were emplaced during the climatic cycles of MIS 12 and 6, respectively. If this can be confirmed, these deposits would significantly post-date formations mapped as equivalents found downstream. Nonetheless, they have produced similar artefact assemblages, dominated by migrating platform cores, handaxes, and flakes (see Copeland, 2004). Only limited numbers of artefacts have been recovered from deposits assigned to the Qf I formation in this area, although a substantial assemblage is known (sites Helouanji 1 and 2) from deposits regarded as stratigraphically equivalent within the valley of the Sajour (Copeland, 2004). Subsequent to the work by Demir et al. (2007a, b), the reach of the Euphrates between Raqqa and Deir ez-Zor has been investigated again by Westaway et al. (2007), including detailed survey (using differential GPS) of heights of terrace deposits and detailed investigation of stratigraphical relationships between basalt flows and fluvial deposits. The principal conclusion to date is that rates of uplift and incision vary laterally in an even more complicated manner than Demir et al. (2007a, b) envisaged.

A noteworthy aspect of the Euphrates record from Syria is the minimal representation of Levallois artefacts within fluvial deposits. The single unequivocal exception is the site of Rhayat (see above). However, Levallois cores and flakes are abundant within collections made from the surface of terrace deposits (e.g., at Chnineh West 1 and Chnineh East 1; see Copeland 2004, p. 47). Given apparent indications that Levallois technology is associated with the deliberate targeting of specific localities in the landscape, and extended curation of Levallois products, this patterning may prove behaviourally informative (Geneste, 1989; Turq, 1989). Re-analysis of extant artefact collections from the Euphrates is currently being undertaken.

7.2. The Orontes

Since 2000, a new terrace record with an archaeological component has been discovered in the upper catchment of the Orontes, south of Homs (Bridgland et al., 2003). Here, a well-preserved staircase of at least 11 terraces up to 200 m above the river is reported (Fig. 2). Funded by the Council for British Research in the Levant, this has formed part of a more general archaeological survey of the Homs district (Philip et al., 2005) and complements earlier surveys of the Orontes terraces further downstream (e.g., Besançon and Sanlaville, 1993; Dodonov et al., 1993). The Upper Orontes terrace deposits, formed as the river cut down progressively into Late Miocene bedrock marl, comprise gravels and finer-grained alluvial sediments, generally highly calcareous and extensively cemented by calcium carbonate. This process has turned the gravels, in particular, into resistant conglomerates that can be readily recognized on the land surface, although in many places they have been broken up and moved to field boundaries through agricultural clearance. The pebbles in these conglomerates include hard cherty (flint) materials, which are the raw material for the stone tools found in the Homs Survey. It is thought, on the basis of occasional in situ discoveries, that the gravels (all but the most ancient ones) contain early artefacts, made at the time the river flowed at the particular level represented. In addition, unrolled surface finds suggest that later tool-makers utilized pebbles from the contemporary river and from pre-existing terrace gravels (Philip et al., 2005). Analyses of conglomerate pebble content have been undertaken, showing that the Upper Orontes gravels are typically much richer in the hard flinty rocks, suitable for tool-making, than are the gravels of local tributaries.

The relative hardness of the conglomerates upstream of Homs has promoted their preservation and has probably led the Orontes to migrate away repeatedly from its former course and incise the bedrock further to the north west (cf. Bridgland, 1985), thus forming one of the most complete terrace staircases anywhere in the world. Like in the Euphrates (Section 7.1), field mapping of these terraces has been aided by the use of differential GPS.

No dating evidence has been discovered thus far in the Upper Orontes, although attempts are underway to apply the uranium-series method to the calcrete cement of terrace conglomerates. Meanwhile, estimated ages of the terraces have been obtained by numerical modelling of the incision since their formation, using the technique described by Westaway et al. (2002). A degree of age constraint for model calibration was achieved by upstream projection of the level of a Middle Pleistocene fossiliferous terrace deposit at Latamneh, ~25 km NW of Hama, which has yielded mid Middle Pleistocene mammal bones (e.g., Dodonov et al., 1993; Bridgland et al., 2003; Schreve et al., 2007). The Latamneh succession is cut into bedrock limestone, and consists of fluvial deposits up to ~30 m thick, the base of which is ~35 m above the current Orontes (Clark, 1967; de Heinzelin, 1968). The lower half of this succession comprises cross-bedded channel gravels containing sand lenses (van Liere, 1960; Clark, 1967). Its upper half consists of alternating layers of coarser and finer gravels, overlain by fluvial sands (Clark, 1967). An important archaeological occurrence (Clark's 'Living Floor' Site; 1967, 1968), consisting of migrating platform cores, hard hammer handaxes and flakes in generally fresh condition, was recovered during excavations at the stratigraphical contact between the lower and upper gravels, some 17 m above the base of the lower gravel (de Heinzelin, 1968).

Using the Latamneh deposits as a pinning point for MIS 12, together with the valley floor deposits as representative of the last climate cycle (Fig. 2), uplift/incision modelling suggests that terrace formation during the Middle and Upper Pleistocene (since ~0.8 Ma) has been in approximate synchrony with 100 ka Milankovitch climatic fluctuation, as with terraces in many parts of Europe (Bridgland and Westaway, 2007, in press; Antoine et al., 2007; Santisteban and Schulte, 2007). The earliest Orontes terraces in this region thus presumably date back to the Early Pleistocene or even the latest Pliocene. Unfortunately, although substantial surface collections have been made in the area, only occasional artefacts have as yet been obtained directly from the terrace deposits around Homs. The cemented nature of these means that they are seldom quarried for aggregates and where exposures exist they cannot be trowelled or dug over in search of artefacts. Surface collections can include artefacts liberated from the deposits by solution, but these are difficult to distinguish from later material, knapped and discarded on the land surface and possibly made using clasts from the underlying gravels.

8. India

Acheulian artefacts from fluvial gravels have been well known in India for over a century (Foote, 1866), but no great antiquity was attributed to this phase in the absence of dating. A common assumption of a Late Middle Pleistocene age was generally made. Acheulian artefacts have been reported from most of the rivers in Peninsular India (Sankalia, 1974). In most cases the 'Acheulian' gravels occur close to the present river level. There is no non-Acheulian Lower Palaeolithic in India, in contrast to other parts of the 'old world' (Mishra, in press). The Soanian, considered the Indian representative of the Asian 'chopper/chopping tool tradition', occurs in sediments younger than those containing Acheulian (Gaillard and Mishra, 2001), and probably should not be considered Lower Palaeolithic at all (Lycett, 2007). Most of the Acheulian occurrences are overlain by late Pleistocene microliths, as is the case at (e.g.) Bori, Morgaon and Nevasa (Rivers Kukdi, Karha, Pravara, respectively). River channels have shifted laterally, rather than vertically; indeed, the remnant patches of Lower and Middle Pleistocene fluvial deposits have survived due to the river shifting laterally, with re-occupation of the ancient position during the phase of late Pleistocene aggradation (Westaway et al., 2003), and exposure of the sediments during the Holocene erosional phase (Mishra et al., 2003). Rivers have aggraded and eroded frequently, mainly in response to Quaternary climate changes. Differing sensitivity to climate is shown by different rivers, with contrasting responses to the same change in climate (Mishra and Rajaguru, 2001; Mishra et al., 2003).

Indian archaeologists never considered it surprising to find Acheulian sediments at the level of the present river or to find them overlain by late Pleistocene, microlithic-bearing sediments, as this is the normal occurrence. One important outcome of the interaction fostered by the IGCP 449 was to make Indians aware of the ubiquitous occurrence of 'terrace staircases' elsewhere and to make Europeans aware of the absence of such sequences in Peninsular India (Westaway et al., 2003; Bridgland and Westaway, 2007). In the absence of absolute dating or the framework of a terrace sequence, the ages of the sediments can only be estimated on the basis of post depositional weathering and other changes. The oldest gravels, which contain Acheulian artefacts, have features indicating differing processes and landscape from the present. Thus the Early Acheulian gravels in the Karha valley at Saswad and Morgaon lack calcrete clasts, which are the most dominant component of the late Pleistocene gravels and have a component of laterite clasts (Rajaguru et al., 2004; Mishra et al., 2007). This is also seen in the Parvati (Abbas, 2006) and Wardha valleys (Shete, 2006). Laterite is absent from the Karha basin today and, while present in the Parvati and Wardha basins, is absent from the parts of these basins contributing sediments to the localities where the Acheulian artefacts have been found. At Nevasa, the Acheulian gravel consists of locally derived regolithic material and pre-dates a phase of bedrock incision in which the Post Acheulian sediments accumulated. Sediments containing Acheulian artefacts show well-developed calcrete formation, reddening of the sediments in some cases, and formation of weathering rind on the basalt pebbles. In contrast to this, late Pleistocene sediments, which contain microliths, show lesser developement of calcrete, yellow brown colours and almost no developement of weathering rinds on basalt pebbles. Holocene sediments rarely show any calcrete accumulation and are brown in colour. Tiwari and Bhai (1997) have recently revised the Quaternary stratigraphy of the Central Narmada valley using these criteria, distinguishing seven formations in contrast to only three previously recognized. Post-depositional changes in the fluvial sediments are difficult to quantify and rates of change can differ from site to site, based on factors other than time, such as type of sediment and climatic parametres. A very imprecise subdivision into three Quaternary units (Holocene, Late Pleistocene and pre-Late Pleistocene) is probably the limit of relative dating. Artefacts are common in the Indian fluvial sediments and are probably a more reliable indicator of age than any other of the 'relative dating' criteria given above. The low level of the gravels containing these early artefact assemblages, in marked contrast with the European situation, is attributed to the great stability of the cratonic crust beneath Peninsular India, which has not seen significant uplift during the Quaternary, unlike regions with younger, more dynamic crust (Westaway et al., 2003).

The Indian Early Acheulian is quite similar to the Early Acheulian in Africa which dates from 1.4 Ma (see below) and would normally be considered an indicator of an age in excess of one million years. Dating of the Acheulian in India has been problematic, with few opportunities for the application of absolute dating techniques. Attempted Th/U dating of a number of Early Acheulian localities in India, including Nevasa, showed that all the localities were beyond the range of Th/U dating (~400 ka) (Mishra, 1992). Late Acheulian artefacts in Pakistan (Rendell and

Dennell, 1985) and Nepal (Corvinus, 1995, 2006) occur in tilted sediments, dated in Pakistan to between 700 and 300 ka. At Bori (Kukdi river), a volcanic ash associated with an Early Acheulian assemblage has been dated to 670 ka (Mishra et al., 1995), while Blackwell et al. (2001) used the ESR technique to date bones associated with the Early Acheulian at Isampur, in Karnataka (Paddayya et al., 2002) and obtained ages >1.2 Ma. ESR dating of calcrete of the Amarpura formation in Rajasthan, which has yielded Late Acheulian artefacts (Misra et al., 1982), has given a date of ~800 ka (Kailath et al., 2001). Most recently palaeomagnetic studies carried out by Sangode et al. (in press), from the three Acheulian sites of Bori, Morgaon and Nevasa, have shown that the sediments associated with the Acheulian artefacts have reversed components, indicating Matuyama age. The limited available data for dating the Early Acheulian in India is thus consistent with a Lower Pleistocene age.

Indian rivers are marked by extreme seasonality, which is important for interpreting the archaeological contexts. Peninsular rivers, in which the Palaeolithic archaeological record is found, are fed by the monsoon rainfall. Typically up to 90% of the discharge is in the rainy months of June October. Within this monsoon season the largest floods occur during rainy spells towards the end of the monsoon, when soils are already saturated. During these flood events discharges may be up to 100 times normal, with a rise in river level of up to 20 m; nevertheless this is confined within the large channels. Local rainfall may also be extreme so that interfluvial areas may be flooded by the overflowing tributaries unable to drain the rain water as fast as the rain falls. Most erosion and deposition occurs during these flood events, which have a duration of hours, rather than days. Observations of archaeological material in the alluvial sediments indicate that many occurences are on the boundaries between depositional units rather than incorporated into them. This means that many sites are buried ancient surfaces rather than fluvially transported assemblages. Integrity of the context varies according to the time period between discard of artefacts by humans and burial by fluvial processes. Recent studies of the Acheulian site of Attirapakkam, near Chennai, discovered over a century ago by Foote, have found the artefacts within a clay deposit, interpreted as of fluvial origin (Gunnell et al., 2006), while the sites of Isampur (Paddayya and Petraglia, 1996/97) and Chirki (von Corvinus, 1983) occur on fluvially eroded bedrock, and are overlain by fluvial deposits. In all these cases the artefacts are minimally disturbed by fluvial processes.

The lack of terraces in the Indian sub-continent is not only due to the relatively stable crust but also the lack of distinct floodplains. In the Narmada River, the largest floods are confined within the banks of the older alluvium. Lower flows occupy the channel within these banks. Gupta et al. (1999) have labelled this as 'a channel in channel' pattern. The effects of tectonics also vary from basin to basin. While the Godavari and Krishna basins, originating from the Sahyadri (western Ghats) divide, show relatively little recent tectonic activity, the rivers originating from Central India, such as the Narmada, Tapi, Purna, Wardha, Wainganga and Son, have been affected by the relatively recent (Quaternary?) formation of the divide. The response to tectonics, as observed in the Narmada River, is seen in the development of alluvial fan facies and channels shifting away from the uplifted divide. Thus in the Nimar region of the Narmada River, the channel has shifted to the north in the Holocene, abandoning the ancient channel to the south, probably in response to uplift of the southern divide (Satpuras).

9. South Africa

Recent research on the lower Vaal has centred on Canteen Koppie (Beaumont and McNabb, 2000), where excavated lithic samples show that basal Stratum 2b, Lower in the Younger Gravels (Rietputs Formation), contains early Acheulian in the age range ~1.6 1.2 Ma. The overlying Stratum 2b, Upper, yielded Acheulian with Levallois. Stratum 2a (overlying 2b, Upper) yielded Acheulian with Levallois and 'Victoria West', thereby suggesting that the latter is a derivative of Levallois, developed for producing cleavers (Sharon and Beaumont, 2006). The large mammal fauna found with widespread lower Vaal occurrences of Acheulian with Levallois and 'Victoria West' can be tentatively correlated with that from Bed IV at Olduvai (Cooke, 1963), dating to ~1.2 0.78 Ma (Delson and Van Coevering, 2000; Antón, 2003). Further upstream, at Riverview Estates, the Vaal Younger Gravels are overlain by up to 10 m of calcified overbank silts and unconsolidated basal sands, in the lower levels of which there is still later Acheulian, typified by the presence of true blades (Malan, 1947). Capping the Vaal succession in many places are red aeolian (Hutton) sands, at the base of which are classic 'middle Fauresmith' assemblages with small handaxes, convex-edged scrapers, refined blades and Levallois points (Söhnge et al., 1937). It has latterly proved possible to date this material using a composite U-series and palaeomagnetic timescale for Wonderwerk Cave, some way to the north, where 'middle Fauresmith' can be related to MIS 13 at ~510 480 ka (Beaumont and Vogel, 2006; Table 2). This ongoing research is therefore providing preliminary evidence for a protracted prior developmental progression at the southern end of Africa, long before Levallois emerged elsewhere in the Old World (Van Riet Lowe, 1945; cf. White and Ashton, 2003).

10. Morocco

The Atlantic coast of Morocco, notably in the vicinity of Casablanca, is a classic area for Palaeolithic archaeology associated with marine terraces. However, in recent years interpretations of the local record have been subjected to significant revision. First, the sequence of historic local chronological stages has been replaced by a modern

Table 2
The South African Palaeolithic sequence, based on the evidence from Wonderwerk Cave and linked to the fluvial record where possible (after Beaumont and Vogel, 2006; see also McNabb, 2001; McNabb et al., 2004)

Period	Industry	Principal characteristics	Approximate dates	Fluvial sites
Later Stone Age			25 ka–recent	
Middle Stone Age	LMSA	No handaxes	0.25 Ma–25 ka	Riverview Estates
	Fauresmith	Small handaxes with blades, Levallois cores and points	~0.62–0.25 Ma	Pniel 6 Canteen Kopie
Earlier Stone Age	Acheulean	Handaxes	Pre – 1.2–~0.62 Ma	Riverview Estates

stratigraphical scheme tied to the Milankovitch forcing of sea-level variations (e.g., Lefevre and Raynal, 2002; Texier et al., 2002) and supported by amino-acid dating, magnetostratigraphy, U-series, OSL, and biostratigraphic age-control (e.g., Occhietti et al., 2002). Second, the notion of an early human occupation of Morocco, as evidenced by apparent ancient 'pebble culture' artefacts, has been superseded by the realisation that these artefacts are either surface finds or are likely to have been naturally produced in high-energy littoral environments (e.g., Raynal et al., 1995b). The modern view is that the earliest evidence of human occupation in this region dates from before the Matuyama-Brunhes boundary, probably from MIS 21 onwards, and that these occupants had a handaxe-making technology throughout (e.g., Raynal and Texier, 1989; Raynal et al., 1995b, 2002). Rhodes et al. (2006) have recently estimated the age of the earliest horizons with Acheulian material at Thomas Quarry, Casablanca, to around 1 Ma using OSL dating techniques. A separate datum is provided by the appearance of evidence of the Levallois technique in Morocco. This appears in a stratigraphical unit known historically as the Anfatian and now designated as Formation 3 of the Anfa Group, corresponding to a marine terrace at ~20 23 m a.s.l. and thought to date from MIS 11 (e.g., Raynal et al., 1995b; Lefevre and Raynal, 2002; Raynal et al., 2002).

In Algeria, on the Mediterranean coast of North Africa, one of the few 'Oldowan' sites outside of East Africa is found at Ain Hanech. Sahouni's reexamination of this site (Sahnouni and de Heinzelin, 1998; Sahnouni et al., 2002; Sahnouni, 2006) has documented an Oldowan lithic industry in sediments assigned to the Olduvai palaeomagnetic event.

11. Synthesis

Palaeolithic archaeology is an important part of the fluvial archive in the Old World. The work summarized here shows how this archive can make a contribution to some of the important issues in Palaeolithic archaeology. River terrace sequences in many parts of Europe, and also, as reported here, in Turkey and Syria, allow a relative sequence of Palaeolithic industries to be identified. Provided that reliable dating contraints are available, correlation between these sequences, with reference to the globally valid oceanic record, is helpful in comparing the Palaeolithic records of widely separated places. Key themes for discussion are the evidence for diachronous appearances of 'Modes 1, 2 and 3' (flake/core, handaxe and prepared-core) industries around the world. Better understanding and documentation of the records from river terraces will assist greatly in determining the extent of such diachroneity.

In Europe, the southern, Mediterranean, areas were occupied earlier than the Northern temperate ones, with the earliest in the south-east (cf. Bridgland et al., 2006). The earliest industries lack handaxes, although the numbers of finds in many cases are too small for this to be diagnostic of 'Mode 1'; such early sites are sparsely distributed in time and space in Europe, ranging from 1.8 Ma at Dmanisi, Georgia, to Early Bruhnes time at Pakefield, UK (see above). Lithic material is in low frequency and stone flaking is primitive, leading de Lumley et al. (2005) to label the Dmanisi assemblage as 'Pre Oldowan'. Well before 500 ka, handaxes appear in some southern European sequences, such as in Iberia and southern Italy (see above), possibly from migrations directly from Africa. Handaxe making (Mode 2) expanded during Middle Pleistocene interglacial periods into NW Europe (Britain and France).

The non-handaxe tradition, in assemblages of diminutive-sized material (recently labelled LPMT: see above), continues in Central and Eastern Europe. Well preserved and excavated sites in Germany, summarized above, show that this tradition was far from primitive, with the preservation of the oldest wooden spears associated with these assemblages (see above, Schöningen). Non-lithic tool components, not preserved in the earlier sites, might be a factor in the primitiveness of the earlier lithic industries also. According to Kozlowski (2003, p. 149), the "demarcation line between the range of 'mode 2' industries and the regions where Acheulian bifaces are not found runs along the Rhine and the Alps, separating the Acheulian in western and southwestern Europe from pebble and flake industries ('mode 1') in central Europe. The line then continues through the Taurus and Caucasus Mountains, separating the Acheulian industries in the Near East and Transcaucasia from the pebble and flake industries of eastern Europe, southeastern Europe, and western Anatolia". He suggested that the Acheulian industries that reached western Europe approximately 500,000 years ago resulted from "of a new wave of migration 'out-of-Africa'" (cf. Carbonell et al., 1999), similar to the emergence of Acheulian industries of African origin in the Near East around 780,000 years ago (cf. Bar Yosef, 1998; Goren-Inbar et al., 2000).

In India and the cratonic region in South Africa, the rivers have not formed terrace sequences and alluvial fills of different ages have an inset relationship to each other. Fluvial processes also differ, mainly due to the extreme seasonality of rainfall. Artefacts are rarely 'washed in' to the fluvial deposits but rather the artefacts discarded on the fluvial sediments are sealed by subsequent depositional episodes. In Africa, the oldest stone tools belong to the Oldowan ('Mode 1') technology, best known from a number of well-preserved and excavated sites in the rift valleys of eastern Africa. The Oldowan, from as early as 2.5 Ma at Gona (Semaw et al., 2003) demonstrates a fairly sophisticated flaking technique. In contrast to the early non-handaxes industries of Europe, Oldowan sites have abundant lithics, with huge amounts of debitage. At 1.4 Ma, a new technology, the Acheulian, makes its appearance in the East African sequence. This Acheulian is quite distinct from its European counterpart, which was much later in time. The innovation of the African Early Acheulian was the use of large flake blanks detached from giant cores, in contrast to the small flakes of the Oldowan. As these giant cores were too large to transport, the transport of the large flakes was built into the Acheulian technology in a way that is absent from the Oldowan technology. The Acheulian and Oldowan occurred together in East Africa until around 1 Ma, according to Schick and Clark (2003). This review highlights the difference in the Indian record. No Oldowan, or LPMT assemblages have ever been identified in India, despite of over 100 years of work. The only Lower Palaeolithic tradition is the Acheulian, and Early Acheulian is found abundantly, especially in the Godavari/Krishna drainage systems. Absolute dating, although, scanty, indicates an age for the Early Acheulian in India comparable with that in Africa.

Current evidence points to two early dispersals of humans to the north-west from Africa. The first, to Mediterranean areas by Mode 1-making people during lower Pleistocene times, would be represented by the Orce sites (e.g. Roe, 1995). An onset for the later one can be deduced from the mt DNA analysis of Ovchinnikov et al. (2000). There are good grounds for accepting the earlier limit of their MRCA estimates: ~250 ka for the origin of *Homo sapiens* and ~850 ka for the *H. sapiens H. neanderthalensis* divergence. According to this interpretation, the immigrants were handaxe-making *H. rhodesiensis* people and their first manifestation outside Africa would be Gesher Benot Ya'aqov, Israel, dated 780,000 BP; Acheulian tools were being made here during MIS 19 18 (e.g. Rink and Schwarcz, 2005). Over time these immigrants evolved into *H heidelbergensis* and then on to *H neanderthalensis*.

The diversity of the Palaeolithic on a global scale is shown by the fluvial records. The earliest stone tools in different regions are all different, which would be unexpected if hominin dispersal from Africa occurred after the beginning of tool use. The first hominin species to be found out of Africa is *Homo erectus/ergatser/georgius*. In Africa the Acheulian appears shortly after the appearance of *Homo ergatser*, while in Georgia *Homo georgius* is associated with a 'pre-Oldowan' industry. In Java, where *H. erectus*, arriving most probably from India (along with a filtered Indian-derived 'Siwalik' fauna), has almost no stone tool associations. Recently bones have been identified with cut marks made with shell tools (Choi and Driwantoro, 2007), bolstering a widely hypothesized idea that non-stone tools might be an important component of the East and SE Asian *H. erectus* toolkit. This leads to a note of caution aimed at those who attempt to determine hominin distribution from lithic artefact assemblages. Data from Europe also show that early people used other raw materials in areas where suitable lithics were absent, as indicated by the occurrence of bone, tusk and wooden tools at sites where preservation quality is exceptional, such as Bilzingsleben (Mania and Mania, 2003; above).

Looking at this amazing contrast in tool assemblages on a global scale, the possibility of an initial migration out of Africa prior to the appearance of stone tools should be seriously considered. India has not been given much consideration in the global senario, due mainly to the lack of hominin fossils and well-dated sites, but given the strong possibility that Early Acheulian technology appeared as early in India as it did in Africa, the record from the subcontinent should now be given renewed priority, as recently suggested by Dennell and Roeboecks (2005). Both *Homo erectus* and the Early Acheulian appear suddenly and synchronously in the well-documented East Africa record. The recent documentation of a 0.5 Ma overlap of *Homo erectus* and *Homo hablis* in East Africa (Spoor et al., 2007) rules out an evolutionary lineage between the two. Considering the occurrence of equally early Early Acheulian material in India, it is perhaps possible that the migration was from India to Africa rather than Africa to India. If this is actually what happened, then the 'out-of-Africa' migration of hominins must have been much earlier and the diverse Palaeolithic record might be just recording the time when the presence of hominins becomes visible due to the use of stone tools. Tool use is increasingly documented by chimpanzees in the wild, so that a period of tool use most probably preceded its visibility in the geological record.

12. Conclusions

The long-timescale fluvial record in regions occupied by pre-*Homo sapiens* hominins can provide a valuable framework for archaeological studies. Many artefact-bearing sites are within fluvial sequences and non-fluvial sites can be considered within the context of the fluvial archive, especially if correlation by biostratigraphy or geochronology is possible. Consideration of the full extent of the database is for the future, but some broad conclusions and suggestions can be offered here:

- There is clear diachroneity between the appearance of hominins and of different technologies in divergent parts of the 'old world'; most things are earlier in Africa.
- There is a zonation of Modes 1/2 industries, with Mode 2 (handaxes) not found in central and eastern Europe.
- The Middle Palaeolithic/Mode 3/Levallois appears significantly earlier in sub-saharan Africa, as part of the Fauresmith, perhaps as early as earliest Middle Pleistocene (Table 2).
- There is considerable uncertainty about the age of the earliesr Palaeolithic in India, but it may well be on a par with Africa.
- In the extreme NW of the area of European records, the earliest occupation has been pushed back significantly by the discoveries at Pakefield, on the east coast of England, perhaps also earliest Middle Pleistocene (see above).
- Levallois (Mode 3) probably appeared in the same NW extremity of the area around MIS 9 8, as judged by evidence from the Solent, southern England.

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